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(57) Abstract

Aqueous liquid detergent compositions are described which comprise a proteolytic enzyme wherein the proteolytic activity is reversibly inhibited by an α-amino boronic acid.

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# LIQUID DETERGENTS CONTAINING AN ALPHA-AMINO BORONIC ACID

## Field of the invention

This invention relates to liquid detergent compositions containing enzymes. More specifically, this invention pertains to liquid detergent compositions containing a detersive surfactant, a proteolytic enzyme, and an α-amino boronic acid.

## Background of the invention

Protease-containing liquid aqueous detergents are well-known, especially in the context of laundry washing. A commonly encountered problem in said protease-containing liquid aqueous detergents is the degradation phenomenon by the proteolytic enzyme of second enzymes in the composition, such as lipase, amylase and cellulase, or the protease itself.

As a result, the stability of the second enzyme or the proteolytic enzyme itself upon storage in the product, and its effect on cleaning are thus both impaired.

Boric acid and boronic acids are well-known to reversibly inhibit proteolytic enzymes. This inhibition of proteolytic enzyme by boronic acid is reversible upon dilution, as in wash water.

It has now been found that certain boronic acids, i.e. α-amino boronic acids are particularly effective reversible protease inhibitors in liquid detergent compositions, so that much lower levels of α-amino boronic acids are needed, compared to other boronic acids, to achieve the same degree of protease inhibition in liquid detergents.

The compositic hus obtained are therefore more environmentally compatible than compc ons comprising other boronic acids, in that less boron is eventually re sed in the environment.

Also, since very levels of α-amino boronic acids are needed for an efficient protease hibition, this allows to free-up several parts of material in the formulation which are then available for other materials. This aspect is particularly critical in the formulation of highly concentrated liquid detergent compositions. These compositions are also encompassed by the present invention.

A discussion of the inhibition of one proteolytic enzyme, subtilisin, is provided in Philipp, M. and Bender, M.L., "Kinetics of Subtilisin and Thiolsubtilisin", Molecular & Cellular Biochemistry, vol. 51, pp. 5-32 (1983).

Copending European Patent Application Serial No. 90/870212 discloses liquid detergent compositions containing certain bacterial serine proteases and lipases.

U.S. Patent 4,566,985 describes liquid cleaning compositions containing a mixture of enzyme at least one of which is a protease. The composition also contains an effective amount of benzamidine hydrochloride to inhibit the digestive effect on the second enzyme.

In European Application 0 376 705, liquid detergents containing a mixture of lipolytic enzymes and proteolytic enzymes have been claimed. The storage stability of lipolytic enzyme towards these proteolytic enzymes is enhanced by inclusion of a lower aliphatic alcohol or lower carboxylic acid.

In European Patent Application 0 381 262, mixtures of proteolytic and lipolytic enzymes in a liquid medium have been disclosed. The stability of lipase is claimed to be improved by the addition of boron compound and a polyol.

In copending European Patent Application 91870072.5, liquid detergent compositions comprising a protease and a second enzyme have

been disclosed wherein the protease is reversibly inhibited by an aromatic borate ester.

In U.S. Patent Applications Serial No. 693,515 and 693,516, liquid detergent compositions comprising a protease and a second enzyme have been disclosed wherein the protease is reversibly inhibited by a boric polyol complex or an aryl boronic acid.

In European Patent Application 0 293 881, peptide boronic acids have been disclosed as reversible inhibitors for trypsin-like serine proteases in a therapeutic application.

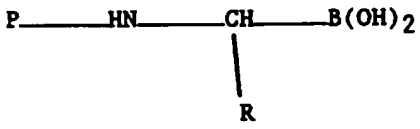
## Summary of the invention

The present invention is a liquid aqueous detergent composition comprising:

-from 1% to 80% of a detersive surfactant,

-from 0.0001% to 0.3% of active proteolytic enzyme or mixtures thereof,

characterized in that it further comprises from about 0.0001% to 5% of an α-amino boronic acid of the formula:




Wherein R is selected from the side chains of the twenty amino acids, and P is H or $(AA2)_m$—$(AA1)_n$—, wherein (AA1) and (AA2) are identical or different amino acids, and n and m are 1 or 0, independently, said α-amino boronic acid possibly comprising an N-terminal protecting group, and mixtures thereof. Preferably, the N-terminal end of the α-amino boronic acid is protected by an acetyl or a benzoyl group.

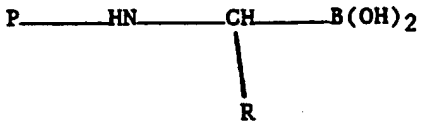
## Detailed description of the invention

The liquid aqueous detergent compositions according to the present invention comprise three essential ingredients: (A) an α-amino boronic acid or mixtures thereof, (B) a proteolytic enzyme or mixtures thereof, and (C) a detersive surfactant. The compositions according to the

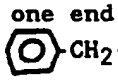
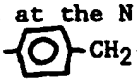
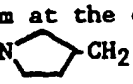
present invention preferably further comprise (D) a detergent-compatible second enzyme or mixtures thereof, and they may also comprise optional ingredients (E).

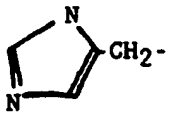
A. α-amino boronic acids:

The detergent compositions according to the present invention comprise a α-amino boronic acid of the formula:

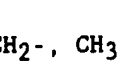


Wherein R is a group selected from the side chains of the twenty amino acids, and P is H or $(AA2)_m$—$(AA1)_n$—, wherein (AA1) and (AA2) are identical or different amino acids, and n and m are 1 or 0, independently, said α-amino boronic acid possibly comprising an N-terminal protecting group, and mixtures thereof.

R is selected from the side chains of the twenty amino acids, i.e. R is selected from H-, $CH_3$-, $(CH_3)_2CH$-, $(CH_3)_2CH$-$CH_2$-, $CH_3$-$CH_2$-$CH(CH_3)$-, -$CH_2$-$CH_2$-$CH_2$- (in the case where R is the side chain from proline, R will be bound to the C atom at one end, and at the N atom at the other end in the formula hereinabove  -$CH_2$-, HO-  -$CH_2$-, HN  -$CH_2$-, $CH_3$-S-$(CH_2)_2$-, $HOCH_2$-, $CH_3$-CH(OH)-, SH-$CH_2$-, $NH_2$-CO-$CH_2$-, $NH_2$-CO-$(CH_2)_2$, HOOC-$CH_2$-, HOOC-$(CH_2)_2$-, $NH_2$-$(CH_2)_4$-, (NH)$(NH_2)$C-NH-$(CH_2)_3$-, and



If R comprises a hydroxy or acidic group, said groups can be protected by using suitable esters or ethers which are well-known in peptide chemistry; typically these groups are protected in the form of t-butyl or benzyl. Also, if R comprises an amino group, said amino group can also be protected by suitable groups well-known in peptide chemistry, such as acetyl, benzoyl, trifluoroacetyl, methoxysuccinyl, aromatic urethane protecting groups such as benzyloxycarbonyl, and aliphatic urethane such as tertbutoxy carbonyl, and the like. Preferred for use herein are hydrophobic R groups such as H-, $CH_3$-, $(CH_3)_2CH$-,

$(CH_3)_2CH-CH_2-$, $CH_3-CH_2-(CH_3)CH$ and  ; most preferred R are  , $(CH_3)_2CH-CH_2-$ and $CH_3-CH_2-(CH_3)CH-$.

P is H or $(AA2)_m$ $(AA1)_n$ , wherein (AA1) and (AA2) are identical or different amino acids, and n and m are 1 or 0, independently. (AA1) and (AA2) are different or similar amino acids selected from Ala, Arg, Asn, Asp, Cys, Gln, Glu, Gly, His, Ile, Leu, Lys, Met, Phe, Pro, Ser, Thr, Trp, Tyr, and val, in their L- or D-configuration, preferably L. The amino, acidic and hydroxy groups of the side chains of AA1 and AA2 may also be protected by appropriate groups well-known in peptide chemistry, as described hereinabove for the amino, acidic and hydroxy groups of R.

The N-terminal end of the α-amino boronic acids according to the present invention can be protected by appropriate groups well-known to the man skilled in the art. These protecting groups include acetyl, benzoyl, trifluoroacetyl, methoxysuccinyl, aromatic urethanes such as benzyloxycarbonyl, aliphatic urethanes such as tertbutoxy carbonyl, and the like.

If P is H, it is the α-amino group itself which can be protected, whereas if n and/or m are 1, it is the N-terminal group of the peptide or the amino acid which may be protected. In a preferred embodiment, the α-amino boronic acids according to the present invention are protected by an acetyl or a benzoyl group.

Most preferred α-amino boronic acids for use herein are :

- 1-acetamido 2-phenylethane -1-boronic acid, i.e. R is  CH2-, P is H and the N-terminal end is protected by an acetyl group;
- 1-benzoylamido methane boronic acid, i.e. R is H, P is H and the N-terminal end is protected by a benzoyl group.

Appropriate methods for synthesizing these compounds are disclosed in the art, in particular in EP 293 881.

The compositions according to the present invention comprise from 0.0001% to 5% by weight of the total composition of said α-amino boronic acid or mixtures thereof. Preferably, the compositions according to the

present invention comprise from 0.001% to 1.0% of said α-amino boronic acid or mixtures thereof, most preferably from 0.005% to 0.5%.

B. Proteolytic Enzyme

A second essential ingredient in the present liquid detergent compositions is from about 0.0001 to 1.0, preferably about 0.0005 to 0.2, most preferably about 0.002 to 0.1, weight % of active proteolytic enzyme. Mixtures of proteolytic enzyme are also included. The proteolytic enzyme can be of animal, vegetable or microorganism (preferred) origin. More preferred is proteolytic enzyme of bacterial origin. Particularly preferred is bacterial serine proteolytic enzyme obtained from Bacillus subtilis and/or Bacillus licheniformis.

Suitable proteolytic enzymes include Novo Industri A/S Alcalase$^{R}$ (preferred), Esperase$^{R}$ , Savinase$^{R}$ (Copenhagen, Denmark), Gist-brocades' Maxatase$^{R}$, Maxacal$^{R}$ , and Maxapem 15$^{R}$ (protein engineered Maxacal$^{R}$) (Delft, Netherlands), and subtilisin BPN and BPN'(preferred), which are commercially available. Preferred proteolytic enzymes are also modified bacterial serine proteases, such as those made by Genencor International, Inc.(San Francisco, California) which are described in European Patent Application Serial Number 87303761.8, filed April 28, 1987 (particularly pages 17, 24 and 98), and which is called herein "Protease B", and 199,404, Venegas, published October 29, 1986, which refers to a modified bacterial serine proteolytic enzyme (Genencor International) which is called "Protease A" herein (same as BNP'). Preferred proteolytic enzymes, then, are selected from the group consisting of Alcalase $^{R}$ (Novo Industri A/S), BPN', Protease A and Protease B (Genencor), and mixtures thereof. Protease B is most preferred.

C. Detersive Surfactant

From about 1 to 80, preferably about 5 to 50, most preferably about 10 to 30, weight % of detersive surfactant is the third essential ingredient in the present invention. The detersive surfactant can be selected from the group consisting of anionics, nonionics, cationics, ampholytics, zwitterionics, and mixtures thereof. Anionic and nonionic surfactants are preferred.

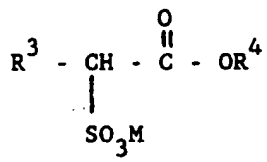
Although heavy duty liquid laundry detergents are the preferred liquid detergent compositions herein, the compositions according to the present invention can be used in a variety of other cleaning applications, such as dishwashing or hard surface cleaning. Accordingly, the particular surfactants used can vary widely depending upon the particular end-use envisioned.

The benefits of the present invention are especially pronounced in compositions containing ingredients that are harsh to enzymes such as certain detergency builders and surfactants. These, in general, include (but are not limited to anionic surfactants such as alkyl ether sulfate linear alkyl benzene sulfonate, alkyl sulfate, etc. Suitable surfactants are described below.

Anionic Surfactants

One type of anionic surfactant which can be utilized encompasses alkyl ester sulfonates. These are desirable because they can be made with renewable, non-petroleum resources. Preparation of the alkyl ester sulfonate surfactant component can be effected according to known methods disclosed in the technical literature. For instance, linear esters of $C_8$-$C_{20}$ carboxylic acids can be sulfonated with gaseous $SO_3$ according to "The Journal of the American Oil Chemists Society," 52 (1975), pp. 323-329. Suitable starting materials would include natural fatty substances as derived from tallow, palm, and coconut oils, etc.

The preferred alkyl ester sulfonate surfactant, especially for laundry applications, comprises alkyl ester sulfonate surfactants of the structural formula:



wherein $R^3$ is a $C_8$-$C_{20}$ hydrocarbyl, preferably an alkyl, or combination thereof, $R^4$ is a $C_1$-$C_6$ hydrocarbyl, preferably an alkyl, or combination

thereof, and M is a soluble salt-forming cation. Suitable salts include metal salts such as sodium, potassium, and lithium salts, and substituted or unsubstituted ammonium salts, such as methyl-, dimethyl, -trimethyl, and quaternary ammonium cations, e.g. tetramethyl-ammonium and dimethyl piperdinium, and cations derived from alkanolamines, e.g. monoethanolamine, diethanolamine, and triethanolamine. Preferably, $R^3$ is $C_{10}$-$C_{16}$ alkyl, and $R^4$ is methyl, ethyl or isopropyl. Especially preferred are the methyl ester sulfonates wherein $R^3$ is $C_{14}$-$C_{16}$ alkyl.

Alkyl sulfate surfactants are another type of anionic surfactant of importance for use herein. In addition to providing excellent overall cleaning ability when used in combination with polyhydroxy fatty acid amides (see below), including good grease/oil cleaning over a wide range of temperatures, wash concentrations, and wash times, dissolution of alkyl sulfates can be obtained, as well as improved formulability in liquid detergent formulations are water soluble salts or acids of the formula $ROSO_3M$ wherein R preferably is a $C_{10}$-$C_{24}$ hydrocarbyl, preferably an alkyl or hydroxyalkyl having a $C_{10}$-$C_{20}$ alkyl component, more preferably a $C_{12}$-$C_{18}$ alkyl or hydroxyalkyl, and M is H or a cation, e.g., an alkali metal cation (e.g., sodium, potassium, lithium), substituted or unsubstituted ammonium cations such as methyl-, dimethyl-, and trimethyl ammonium and quaternary ammonium cations, e.g., tetramethyl-ammonium and dimethyl piperdinium, and cations derived from alkanolamines such as ethanolamine, diethanolamine, triethanolamine, and mixtures thereof, and the like. Typically, alkyl chains of $C_{12-16}$ are preferred for lower wash temperatures (e.g., below about 50°C) and $C_{16-18}$ alkyl chains are preferred for higher wash temperatures (e.g., above about 50°C).

Alkyl alkoxylated sulfate surfactants are another category of useful anionic surfactant. These surfactants are water soluble salts or acids typically of the formula $RO(A)_mSO_3M$ wherein R is an unsubstituted $C_{10}$-$C_{24}$ alkyl or hydroxyalkyl group having a $C_{10}$-$C_{24}$ alkyl component, preferably a $C_{12}$-$C_{20}$ alkyl or hydroxyalkyl, more preferably $C_{12}$-$C_{18}$ alkyl or hydroxyalkyl, A is an ethoxy or propoxy unit, m is greater than zero, typically between about 0.5 and about 6, more preferably between about 0.5 and about 3, and M is H or a cation which can be, for example, a metal cation (e.g., sodium, potassium, lithium, calcium, magnesium,

etc.), ammonium or substituted-ammonium cation. Alkyl ethoxylated sulfates as well as alkyl propoxylated sulfates are contemplated herein. Specific examples of substituted ammonium cations include methyl-, dimethyl-, trimethyl-ammonium and quaternary ammonium cations, such as tetramethyl-ammonium, dimethyl piperdinium and cations derived from alkanolamines, e.g. monoethanolamine, diethanolamine, and triethanolamine, and mixtures thereof. Exemplary surfactants are $C_{12}$-$C_{18}$ alkyl polyethoxylate (1.0) sulfate, $C_{12}$-$C_{18}$ alkyl polyethoxylate (2.25) sulfate, $C_{12}$-$C_{18}$ alkyl polyethoxylate (3.0) sulfate, and $C_{12}$-$C_{18}$ alkyl polyethoxylate (4.0) sulfate wherein M is conveniently selected from sodium and potassium.

Other Anionic Surfactants

Other anionic surfactants useful for detersive purposes can also be included in the compositions hereof. These can include salts (including, for example, sodium, potassium, ammonium, and substituted ammonium salts such as mono-, di- and triethanolamine salts) of soap, $C_9$-$C_{20}$ linear alkylbenzenesulphonates, $C_8$-$C_{22}$ primary or secondary alkanesulphonates, $C_8$-$C_{24}$ olefinsulphonates, sulphonated polycarboxylic acids prepared by sulphonation of the pyrolyzed product of alkaline earth metal citrates, e.g., as described in British patent specification No. 1,082,179, alkyl glycerol sulfonates, fatty acyl glycerol sulfonates, fatty oleyl glycerol sulfates, alkyl phenol ethylene oxide ether sulfates, paraffin sulfonates, alkyl phosphates, isethionates such as the acyl isethionates, N-acyl taurates, fatty acid amides of methyl tauride, alkyl succinamates and sulfosuccinates, monoesters of sulfosuccinate (especially saturated and unsaturated $C_{12}$-$C_{18}$ monoesters) diesters of sulfosuccinate (especially saturated and unsaturated $C_6$-$C_{14}$ diesters), N-acyl sarcosinates, sulfates of alkylpolysaccharides such as the sulfates of alkylpolyglucoside (the nonionic nonsulfated compounds being described below), branched primary alkyl sulfates, alkyl polyethoxy carboxylates such as those of the formula $RO(CH_2CH_2O)_kCH_2COO\text{-}M^+$ wherein R is a $C_8$-$C_{22}$ alkyl, k is an integer from 0 to 10, and M is a soluble salt-forming cation, and fatty acids esterified with isethionic acid and neutralized with sodium hydroxide. Resin acids and hydrogenated resin acids are also suitable, such as rosin, hydrogenated rosin, and resin acids and

hydrogenated resin acids present in or derived from tall oil. Further examples are given in "Surface Active Agents and Detergents" (Vol. I and II by Schwartz, Perry and Berch). A variety of such surfactants are also generally disclosed in U.S. Patent 3,929,678, issued December 30, 1975 to Laughlin, et al. at Column 23, line 58 through Column 29, line 23 (herein incorporated by reference).

Nonionic Detergent Surfactants

Suitable nonionic detergent surfactants are generally disclosed in U.S. Patent 3,929,678, Laughlin et al., issued December 30, 1975, at column 13, line 14 through column 16, line 6, incorporated herein by reference. Exemplary, non-limiting classes of useful nonionic surfactants are listed below.

1. The polyethylene, polypropylene, and polybutylene oxide condensates of alkyl phenols. In general, the polyethylene oxide condensates are preferred. These compounds include the condensation products of alkyl phenols having an alkyl group containing from about 6 to about 12 carbon atoms in either a straight chain or branched chain configuration with the alkylene oxide. In a preferred embodiment, the ethylene oxide is present in an amount equal to from about 5 to about 25 moles of ethylene oxide per mole of alkyl phenol. Commercially available nonionic surfactants of this type include Igepal$^{R}$ CO-630, marketed by the GAF Corporation; and Triton$^{R}$ X-45, X-114, X-100, and X-102, all marketed by the Rohm & Haas Company. These compounds are commonly referred to as alkyl phenol alkoxylates, (e.g., alkyl phenol ethoxylates).

2. The condensation products of aliphatic alcohols with from about 1 to about 25 moles of ethylene oxide. The alkyl chain of the aliphatic alcohol can either be straight or branched, primary or secondary, and generally contains from about 8 to about 22 carbon atoms. Particularly preferred are the condensation products of alcohols having an alkyl group containing from about 10 to about 20 carbon atoms with from about 2 to about 18 moles of ethylene oxide per mole of alcohol. Examples of commercially available nonionic surfactants of this type include Tergitol$^{TM}$ 15-S-9 (the condensation product of $C_{11}$-$C_{15}$ linear

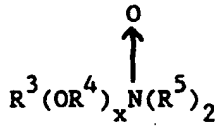
secondary alcohol with 9 moles ethylene oxide), Tergitol$^{TM}$ 24-L-6 NMW (the condensation product of $C_{12}$-$C_{14}$ primary alcohol with 6 moles ethylene oxide with a narrow molecular weight distribution), both marketed by Union Carbide Corporation; Neodol$^{R}$ 45-9 (the condensation product of $C_{14}$-$C_{15}$ linear alcohol with 9 moles of ethylene oxide), Neodol$^{R}$ 23-6.5 (the condensation product of $C_{12}$-$C_{13}$ linear alcohol with 6.5 moles of ethylene oxide), Neodol$^{R}$ 45-7 (the condensation product of $C_{14}$-$C_{15}$ linear alcohol with 7 moles of ethylene oxide), Neodol$^{R}$ 45-4 (the condensation product of $C_{14}$-$C_{15}$ linear alcohol with 4 moles of ethylene oxide), marketed by Shell Chemical Company, and Kyro$^{R}$ EOB (the condensation product of $C_{13}$-$C_{15}$ alcohol with 9 moles ethylene oxide), marketed by The Procter & Gamble Company. This category of nonionic surfactant is referred to generally as "alkyl ethoxylates."

3. The condensation products of ethylene oxide with a hydrophobic base formed by the condensation of propylene oxide with propylene glycol. The hydrophobic portion of these compounds preferably has a molecular weight of from about 1500 to about 1800 and exhibits water insolubility. The addition of polyoxyethylene moieties to this hydrophobic portion tends to increase the water solubility of the molecule as a whole, and the liquid character of the product is retained up to the point where the polyoxyethylene content is about 50% of the total weight of the condensation product, which corresponds to condensation with up to about 40 moles of ethylene oxide. Examples of compounds of this type include certain of the commercially-available Pluronic$^{R}$ surfactants, marketed by BASF.

4. The condensation products of ethylene oxide with the product resulting from the reaction of propylene oxide and ethylenediamine. The hydrophobic moiety of these products consists of the reaction product of ethylenediamine and excess propylene oxide, and generally has a molecular weight of from about 2500 to about 3000. This hydrophobic moiety is condensed with ethylene oxide to the extent that the condensation product contains from about 40% to about 80% by weight of polyoxyethylene and has a molecular weight of from about 5,000 to about 11,000. Examples of this type of nonionic surfactant include certain of the commercially available Tetronic$^{R}$ compounds, marketed by BASF.

5. Semi-polar nonionic surfactants are a special category of nonionic surfactants which include water-soluble amine oxides containing one alkyl moiety of from about 10 to about 18 carbon atoms and 2 moieties selected from the group consisting of alkyl groups and hydroxyalkyl groups containing from about 1 to about 3 carbon atoms; water-soluble phosphine oxides containing one alkyl moiety of from about 10 to about 18 carbon atoms and 2 moieties selected from the group consisting of alkyl groups and hydroxyalkyl groups containing from about 1 to about 3 carbon atoms; and water-soluble sulfoxides containing one alkyl moiety of from about 10 to about 18 carbon atoms and a moiety selected from the group consisting of alkyl and hydroxyalkyl moieties of from about 1 to about 3 carbon atoms.

Semi-polar nonionic detergent surfactants include the amine oxide surfactants having the formula



wherein $R^3$ is an alkyl, hydroxyalkyl, or alkyl phenyl group or mixtures thereof containing from about 8 to about 22 carbon atoms; $R^4$ is an alkylene or hydroxyalkylene group containing from about 2 to about 3 carbon atoms or mixtures thereof; x is from 0 to about 3; and each $R^5$ is an alkyl or hydroxyalkyl group containing from about 1 to about 3 carbon atoms or a polyethylene oxide group containing from about 1 to about 3 ethylene oxide groups. The $R^5$ groups can be attached to each other, e.g., through an oxygen or nitrogen atom, to form a ring structure.

These amine oxide surfactants in particular include $C_{10}$-$C_{18}$ alkyl dimethyl amine oxides and $C_8$-$C_{12}$ alkoxy ethyl dihydroxy ethyl amine oxides.

6. Alkylpolysaccharides disclosed in U.S. Patent 4,565,647, Llenado, issued January 21, 1986, having a hydrophobic group containing from about 6 to about 30 carbon atoms, preferably from about 10 to about 16 carbon atoms and a polysaccharide, e.g., a polyglycoside, hydrophilic

group containing from about 1.3 to about 10, preferably from about 1.3 to about 3, most preferably from about 1.3 to about 2.7 saccharide units. Any reducing saccharide containing 5 or 6 carbon atoms can be used, e.g., glucose, galactose and galactosyl moieties can be substituted for the glucosyl moieties. (Optionally the hydrophobic group is attached at the 2-, 3-, 4-, etc. positions thus giving a glucose or galactose as opposed to a glucoside or galactoside.) The intersaccharide bonds can be, e.g., between the one position of the additional saccharide units and the 2-, 3-, 4-, and/or 6- positions on the preceding saccharide units.

Optionally, and less desirably, there can be a polyalkylene-oxide chain joining the hydrophobic moiety and the polysaccharide moiety. The preferred alkyleneoxide is ethylene oxide. Typical hydrophobic groups include alkyl groups, either saturated or unsaturated, branched or unbranched containing from about 8 to about 18, preferably from about 10 to about 16, carbon atoms. Preferably, the alkyl group is a straight chain saturated alkyl group. The alkyl group can contain up to about 3 hydroxy groups and/or the polyalkyleneoxide chain can contain up to about 10, preferably less than 5, alkyleneoxide moieties. Suitable alkyl polysaccharides are octyl, nonyldecyl, undecyldodecyl, tridecyl, tetradecyl, pentadecyl, hexadecyl, heptadecyl, and octadecyl, di-, tri-, tetra-, penta-, and hexaglucosides, galactosides, lactosides, glucoses, fructosides, fructoses and/or galactoses. Suitable mixtures include coconut alkyl, di-, tri-, tetra-, and pentaglucosides and tallow alkyl tetra-, penta-, and hexa-glucosides.

The preferred alkylpolyglycosides have the formula

$$R^2O(C_nH_{2n}O)_t(\text{glycosyl})_x$$

wherein $R^2$ is selected from the group consisting of alkyl, alkyl-phenyl, hydroxyalkyl, hydroxyalkylphenyl, and mixtures thereof in which the alkyl groups contain from about 10 to about 18, preferably from about 12 to about 14, carbon atoms; n is 2 or 3, preferably 2; t is from 0 to about 10, preferably 0; and x is from about 1.3 to about 10, preferably from about 1.3 to about 3, most preferably from about 1.3 to about 2.7. The glycosyl is preferably derived from glucose. To prepare these compounds,

the alcohol or alkylpolyethoxy alcohol is formed first and then reacted with glucose, or a source of glucose, to form the glucoside (attachment at the 1-position). The additional glycosyl units can then be attached between their 1-position and the preceding glycosyl units 2-, 3-, 4- and/or 6-position, preferably predominantly the 2-position.

7. Fatty acid amide surfactants having the formula:

$$R^6 - \overset{O}{\overset{\|}{C}} - N(R^7)_2$$

wherein $R^6$ is an alkyl group containing from about 7 to about 21 (preferably from about 9 to about 17) carbon atoms and each $R^7$ is selected from the group consisting of hydrogen, $C_1$-$C_4$ alkyl, $C_1$-$C_4$ hydroxyalkyl, and $-(C_2H_4O)_xH$ where x varies from about 1 to about 3.

Preferred amides are $C_8$-$C_{20}$ ammonia amides, monoethanolamides, diethanolamides, and isopropanolamides.

Cationic Surfactants

Cationic detersive surfactants can also be included in detergent compositions of the present invention. Cationic surfactants include the ammonium surfactants such as alkyldimethylammonium halogenides, and those surfactants having the formula:

$$[R^2(OR^3)_y][R^4(OR^3)_y]_2R^5N^+X^-$$

wherein $R^2$ is an alkyl or alkyl benzyl group having from about 8 to about 18 carbon atoms in the alkyl chain, each $R^3$ is selected from the group consisting of $-CH_2CH_2-$, $-CH_2CH(CH_3)-$, $-CH_2CH(CH_2OH)-$, $-CH_2CH_2CH_2-$, and mixtures thereof; each $R^4$ is selected from the group consisting of $C_1$-$C_4$ alkyl, $C_1$-$C_4$ hydroxyalkyl, benzyl, ring structures formed by joining the two $R^4$ groups, $-CH_2CHOH-CHOHCOR^6CHOHCH_2OH$ wherein $R^6$ is any hexose or hexose polymer having a molecular weight less than about 1000, and hydrogen when y is not 0; $R^5$ is the same as $R^4$ or is an alkyl chain

wherein the total number of carbon atoms of $R^2$ plus $R^5$ is not more than about 18; each y is from 0 to about 10 and the sum of the y values is from 0 to about 15; and X is any compatible anion.

Other cationic surfactants useful herein are also described in U.S. Patent 4,228,044, Cambre, issued October 14, 1980, incorporated herein by reference.

Other Surfactants

Ampholytic surfactants can be incorporated into the detergent compositions hereof. These surfactants can be broadly described as aliphatic derivatives of secondary or tertiary amines, or aliphatic derivatives of heterocyclic secondary and tertiary amines in which the aliphatic radical can be straight chain or branched. One of the aliphatic substituents contains at least about 8 carbon atoms, typically from about 8 to about 18 carbon atoms, and at least one contains an anionic water-solubilizing group, e.g., carboxy, sulfonate, sulfate. See U.S. Patent No. 3,929,678 to Laughlin et al., issued December 30, 1975 at column 19, lines 18-35 (herein incorporated by reference) for examples of ampholytic surfactants.

Zwitterionic surfactants can also be incorporated into the detergent compositions hereof. These surfactants can be broadly described as derivatives of secondary and tertiary amines, derivatives of heterocyclic secondary and tertiary amines, or derivatives of quaternary ammonium, quaternary phosphonium or tertiary sulfonium compounds. See U.S. Patent No. 3,929,678 to Laughlin et al., issued December 30, 1975 at column 19, line 38 through column 22, line 48 (herein incorporated by reference) for examples of zwitterionic surfactants.

Ampholytic and zwitterionic surfactants are generally used in combination with one or more anionic and/or nonionic surfactants.

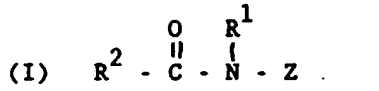
Polyhydroxy Fatty Acid Amide Surfactant

The liquid detergent compositions hereof preferably contain an "enzyme performance-enhancing amount" of polyhydroxy fatty acid amide

surfactant. By "enzyme-enhancing" is meant that the formulator of the composition can select an amount of polyhydroxy fatty acid amide to be incorporated into the compositions that will improve enzyme cleaning performance of the detergent composition. In general, for conventional levels of enzyme, the incorporation of about 1%, by weight, polyhydroxy fatty acid amide will enhance enzyme performance.

The detergent compositions hereof will typically comprise at least about 1% weight basis, polyhydroxy fatty acid amide surfactant and preferably at least from about 3% to about 50%, most preferably from about 3% to 30%, of the polyhydroxy fatty acid amide.

The polyhydroxy fatty acid amide surfactant component comprises compounds of the structural formula:



(I) $R^2 - C(=O) - N(R^1) - Z$

wherein: $R^1$ is H, $C_1$-$C_4$ hydrocarbyl, 2-hydroxy ethyl, 2-hydroxy propyl, or a mixture thereof, preferably $C_1$-$C_4$ alkyl, more preferably $C_1$ or $C_2$ alkyl, most preferably $C_1$ alkyl (i.e., methyl); and $R^2$ is a $C_5$-$C_{31}$ hydrocarbyl, preferably straight chain $C_7$-$C_{19}$ alkyl or alkenyl, more preferably straight chain $C_9$-$C_{17}$ alkyl or alkenyl, most preferably straight chain $C_{11}$-$C_{15}$ alkyl or alkenyl, or mixtures thereof; and Z is a polyhydroxyhydrocarbyl having a linear hydrocarbyl chain with at least 3 hydroxyls directly connected to the chain, or an alkoxylated derivative (preferably ethoxylated or propoxylated) thereof. Z preferably will be derived from a reducing sugar in a reductive amination reaction; more preferably Z will be a glycityl. Suitable reducing sugars include glucose, fructose, maltose, lactose, galactose, mannose, and xylose. As raw materials, high dextrose corn syrup, high fructose corn syrup, and high maltose corn syrup can be utilized as well as the individual sugars listed above. These corn syrups may yield a mix of sugar components for Z. It should be understood that it is by no means intended to exclude other suitable raw materials. Z preferably will be selected from the group consisting of $-CH_2-(CHOH)_n-CH_2OH$, $-CH(CH_2OH)-(CHOH)_{n-1}-CH_2OH$,

$-CH_2-(CHOH)_2(CHOR')(CHOH)-CH_2OH$, and alkoxylated derivatives thereof, where n is an integer from 3 to 5, inclusive, and R' is H or a cyclic or aliphatic monosaccharide. Most preferred are glycityls wherein n is 4, particularly $-CH_2-(CHOH)_4-CH_2OH$.

In Formula (I), R' can be, for example, N-methyl, N-ethyl, N-propyl, N-isopropyl, N-butyl, N-2-hydroxy ethyl, or N-2-hydroxy propyl.

R2-CO-N< can be, for example, cocamide, stearamide, oleamide, lauramide, myristamide, capricamide, palmitamide, tallowamide, etc.

Z can be 1-deoxyglucityl, 2-deoxyfructityl, 1-deoxymaltityl, 1-deoxylactityl, 1-deoxygalactityl, 1-deoxymannityl, 1-deoxymaltotriotityl, etc.

Methods for making polyhydroxy fatty acid amides are known in the art. In general, they can be made by reacting an alkyl amine with a reducing sugar in a reductive amination reaction to form a corresponding N-alkyl polyhydroxyamine, and then reacting the N-alkyl polyhydroxyamine with a fatty aliphatic ester or triglyceride in a condensation/amidation step to form the N-alkyl, N-polyhydroxy fatty acid amide product. Processes for making compositions containing polyhydroxy fatty acid amides are disclosed, for example, in G.B. Patent Specification 809,060, published February 18, 1959, by Thomas Hedley & Co., Ltd., U.S. Patent 2,965,576, issued December 20, 1960 to E. R. Wilson, and U.S. Patent 2,703,798, Anthony M. Schwartz, issued March 8, 1955, and U.S. Patent 1,985,424, issued December 25, 1934 to Piggott, each of which is incorporated herein by reference.

D. Second Enzyme

Preferred compositions herein further comprise a performance-enhancing amount of a detergent-compatible second enzyme. By "detergent-compatible" is meant compatibility with the other ingredients of a liquid detergent composition, such as detersive surfactant and detergency builder. These second enzymes are preferably selected from the group consisting of lipase, amylase, cellulase, and mixtures thereof. The term "second enzyme" excludes the proteolytic enzymes discussed above, so each

composition contains at least two kinds of enzyme, including at least one proteolytic enzyme. The amount of second enzyme used in the composition varies according to the type of enzyme. In general, from about 0.0001 to 0.3, more preferably 0.001 to 0.1, weight % of these second enzymes are preferably used. Mixtures of the same class of enzymes (e.g. lipase) or two or more classes (e.g. cellulase and lipase) may be used. Purified or non-purified forms of the enzyme may be used.

Any lipolytic enzyme suitable for use in a liquid detergent composition can be used in these compositions. Suitable lipase enzymes for use herein include those of bacterial and fungal origin.

Suitable bacterial lipases include those produced by microorganisms of the Pseudomonas groups, such as Pseudomonas stutzeri ATCC 19.154, as disclosed in British Patent 1,372,034, incorporated herein by reference. Suitable lipases include those which show a positive immunological cross-reaction with the antibody of the lipase produced by the microorganism Pseudomonas fluorescens IAM 1057. This lipase and a method for its purification have been described in Japanese Patent Application 53-20487, laid open on February 24, 1978. This lipase is available from Amano Pharmaceutical Co. Ltd., Nagoya, Japan, under the trade name Lipase P "Amano," hereinafter referred to as "Amano-P." Such lipases should show a positive immunological cross-reaction with the Amano-P antibody, using the standard and well-known immunodiffusion procedure according to Ouchterlony (Acta. Med. Scan., 133, pages 76-79 (1950)). These lipases, and a method for their immunological cross-reaction with Amano-P, are also described in U.S. Patent 4,707,291, Thom et al., issued November 17, 1987, incorporated herein by reference. Typical examples thereof are the Amano-P lipase, the lipase ex Pseudomonas fragi FERM P 1339 (available under the trade name Amano-B), lipase ex Pseudomonas nitroreducens var. lipolyticum FERM P 1338 (available under the trade name Amano-CES), lipases ex Chromobacter viscosum, e.g. Chromobacter viscosum var. lipolyticum NRRLB 3673, commercially available from Toyo Jozo Co., Tagata, Japan; and further Chromobacter viscosum lipases from U.S. Biochemical Corp., U.S.A. and Disoynth Co., The Netherlands, and lipases ex Pseudomonas gladioli.

Suitable fungal lipases include those producible by Humicola lanuginosa and Thermomyces lanuginosus. Most preferred is lipase obtained by cloning the gene from Humicola lanuginosa and expressing the gene in Aspergillus oryzae as described in European Patent Application 0 258 068 (Novo Industri A/S), commercially available from Novo Nordisk A/S under the trade name Lipolase$^{R}$.

From about 10 to 18,000, preferably about 60 to 6,000, lipase units per gram (LU/g) of lipase can be used in these compositions. A lipase unit is that amount of lipase which produces 1 μmol of titratable fatty acid per minute in a pH stat, where pH is 9.0, temperature is 30°C, substrate is an emulsion of 3.3wt % of olive oil and 3.3% gum arabic, in the presence of 13 μmol/l $Ca^{++}$ and 20 μmol/l NaCl in 5 μmol/l Tris-buffer.

Any cellulase suitable for use in a liquid detergent composition can be used in these compositions. Suitable cellulase enzymes for use herein include those from bacterial and fungal origins. Preferably, they will have a pH optimum of between 5 and 9.5. From about 0.0001 to 0.1 weight % cellulase can be used.

Suitable cellulases are disclosed in U.S. Patent 4,435,307, Barbesgaard et al., issued March 6, 1984, incorporated herein by reference, which discloses fungal cellulase produced from Humicola insolens. Suitable cellulases are also disclosed in GB-A-2.075.028, GB-A-2.095.275 and DE-OS-2.247.832.

Examples of such cellulases are cellulases produced by a strain of Humicola insolens (Humicola grisea var. thermoidea), particularly the Humicola strain DSM 1800, and cellulases produced by a fungus of Bacillus N or a cellulase 212-producing fungus belonging to the genus Aeromonas, and cellulase extracted from the hepatopancreas of a marine mollusc (Dolabella Auricula Solander).

Any amylase suitable for use in a liquid detergent composition can be used in these compositions. Amylases include, for example, amylases obtained from a special strain of B.licheniforms, described in more detail in British Patent Specification No. 1,296,839 (Novo). Amylolytic

proteins include, for example, Rapidase$^{R}$, International Bio-Synthetics, Inc. and Termamyl$^{R}$ Novo Industries.

From about 0.0001% to 0.55, preferably 0.0005 to 0.1, wt. % amylase can be used.

E. Optional Ingredients

Detergent builders can optionally be included in the compositions herein. From 0 to about 50 weight % detergency builder can be used herein. Inorganic as well as organic builders can be used. When present, the compositions will typically comprise at least about 1% builder. Liquid formulations preferably comprise from about 3% to 30%, more preferably about 5 to 20%, by weight, of detergent builder.

Inorganic detergent builders include, but are not limited to, the alkali metal, ammonium and alkanolammonium salts of polyphosphates (exemplified by the tripolyphosphates, pyrophosphates, and glassy polymeric meta-phosphates), phosphonates, phytic acid, silicates, carbonates (including bicarbonates and sesquicarbonates), sulphates, and aluminosilicates. Borate builders, as well as builders containing borate-forming materials that can produce borate under detergent storage or wash conditions (hereinafter, collectively "borate builders"), can also be used. Preferably, non-borate builders are used in the compositions of the invention intended for use at wash conditions less than about 50°C, especially less than about 40°C.

Examples of silicate builders are the alkali metal silicates, particularly those having a $SiO_2$:$Na_2O$ ratio in the range 1.6:1 to 3.2:1 and layered silicates, such as the layered sodium silicates described in U.S. Patent 4,664,839, issued May 12, 1987 to H. P. Rieck, incorporated herein by reference. However, other silicates may also be useful such as for example magnesium silicate, which can serve as a crispening agent in granular formulations, as a stabilizing agent for oxygen bleaches, and as a component of suds control systems.

Examples of carbonate builders are the alkaline earth and alkali metal carbonates, including sodium carbonate and sesquicarbonate and

mixtures thereof with ultra-fine calcium carbonate as disclosed in German Patent Application No. 2,321,001 published on November 15, 1973, the disclosure of which is incorporated herein by reference.

Aluminosilicate builders are useful in the present invention. Aluminosilicate builders are of great importance in most currently marketed heavy duty granular detergent compositions, and can also be a significant builder ingredient in liquid detergent formulations. Aluminosilicate builders include those having the empirical formula:

$$M_z(zAlO_2 \cdot ySiO_2)$$

wherein M is sodium, potassium, ammonium or substituted ammonium, z is from about 0.5 to about 2; and y is 1; this material having a magnesium ion exchange capacity of at least about 50 milligram equivalents of $CaCO_3$ hardness per gram of anhydrous aluminosilicate. Preferred aluminosilicates are zeolite builders which have the formula:

$$Na_z[(AlO_2)_z\ (SiO_2)_y] \cdot xH_2O$$

wherein z and y are integers of at least 6, the molar ratio of z to y is in the range from 1.0 to about 0.5, and x is an integer from about 15 to about 264.

Useful aluminosilicate ion exchange materials are commercially available. These aluminosilicates can be crystalline or amorphous in structure and can be naturally-occurring aluminosilicates or synthetically derived. A method for producing aluminosilicate ion exchange materials is disclosed in U.S. Patent 3,985,669, Krummel, et al., issued October 12, 1976, incorporated herein by reference. Preferred synthetic crystalline aluminosilicate ion exchange materials useful herein are available under the designations Zeolite A, Zeolite P (B), and Zeolite X. In an especially preferred embodiment, the crystalline aluminosilicate ion exchange material has the formula:

$$Na_{12}[(AlO_2)_{12}(SiO_2)_{12}] \cdot xH_2O$$

wherein x is from about 20 to about 30, especially about 27. This material is known as Zeolite A. Preferably, the aluminosilicate has a particle size of about 0.1-10 microns in diameter.

Specific examples of polyphosphates are the alkali metal tripolyphosphates, sodium, potassium and ammonium pyrophosphate, sodium and potassium and ammonium pyrophosphate, sodium and potassium orthophosphate, sodium polymeta phosphate in which the degree of polymerization ranges from about 6 to about 21, and salts of phytic acid.

Examples of phosphonate builder salts are the water-soluble salts of ethane 1-hydroxy-1, 1-diphosphonate particularly the sodium and potassium salts, the water-soluble salts of methylene diphosphonic acid e.g. the trisodium and tripotassium salts and the water-soluble salts of substituted methylene diphosphonic acids, such as the trisodium and tripotassium ethylidene, isopyropylidene benzylmethylidene and halo methylidene phosphonates. Phosphonate builder salts of the aforementioned types are disclosed in U.S. Patent Nos. 3,159,581 and 3,213,030 issued December 1, 1964 and October 19, 1965, to Diehl; U.S. Patent No. 3,422,021 issued January 14, 1969, to Roy; and U.S. Patent Nos. 3,400,148 and 3,422,137 issued September 3, 1968, and January 14, 1969 to Quimby, said disclosures being incorporated herein by reference.

Organic detergent builders preferred for the purposes of the present invention include a wide variety of polycarboxylate compounds. As used herein, "polycarboxylate" refers to compounds having a plurality of carboxylate groups, preferably at least 3 carboxylates.

Polycarboxylate builder can generally be added to the composition in acid form, but can also be added in the form of a neutralized salt. When utilized in salt form, alkali metals, such as sodium, potassium, and lithium, or alkanolammonium salts are preferred.

Included among the polycarboxylate builders are a variety of categories of useful materials. One important category of polycarboxylate builders encompasses the ether polycarboxylates. A number of ether polycarboxylates have been disclosed for use as detergent builders. Examples of useful ether polycarboxylates include

oxydisuccinate, as disclosed in Berg, U.S. Patent 3,128,287, issued April 7, 1964, and Lamberti et al., U.S. Patent 3,635,830, issued January 18, 1972, both of which are incorporated herein by reference.

A specific type of ether polycarboxylates useful as builders in the present invention also include those having the general formula:

$$CH(A)(COOX)-CH(COOX)-O-CH(COOX)-CH(COOX)(B)$$

wherein A is H or OH; B is H or $-O-CH(COOX)-CH_2(COOX)$; and X is H or a salt-forming cation. For example, if in the above general formula A and B are both H, then the compound is oxydissuccinic acid and its water-soluble salts. If A is OH and B is H, then the compound is tartrate monosuccinic acid (TMS) and its water-soluble salts. If A is H and B is $-O-CH(COOX)-CH_2(COOX)$, then the compound is tartrate disuccinic acid (TDS) and its water-soluble salts. Mixtures of these builders are especially preferred for use herein. Particularly preferred are mixtures of TMS and TDS in a weight ratio of TMS to TDS of from about 97:3 to about 20:80. These builders are disclosed in U.S. Patent 4,663,071, issued to Bush et al., on May 5, 1987.

Suitable ether polycarboxylates also include cyclic compounds, particularly alicyclic compounds, such as those described in U.S. Patents 3,923,679; 3,835,163; 4,158,635; 4,120,874 and 4,102,903, all of which are incorporated herein by reference.

Other useful detergency builders include the ether hydroxypolycarboxylates represented by the structure:

$$HO-[C(R)(COOM)-C(R)(COOM)-O]_n-H$$

wherein M is hydrogen or a cation wherein the resultant salt is water-soluble, preferably an alkali metal, ammonium or substituted ammonium cation, n is from about 2 to about 15 (preferably n is from about 2 to about 10, more preferably n averages from about 2 to about 4) and each R is the same or different and selected from hydrogen, $C_{1-4}$ alkyl or $C_{1-4}$ substituted alkyl (preferably R is hydrogen).

Still other ether polycarboxylates include copolymers of maleic anhydride with ethylene or vinyl methyl ether, 1, 3, 5-trihydroxy benzene-2, 4, 6-trisulphonic acid, and carboxymethyloxysuccinic acid.

Organic polycarboxylate builders also include the various alkali metal, ammonium and substituted ammonium salts of polyacetic acids. Examples include the sodium, potassium, lithium, ammonium and substituted ammonium salts of ethylenediamine tetraacetic acid, and nitrilotriacetic acid.

Also included are polycarboxylates such as mellitic acid, succinic acid, oxydisuccinic acid, polymaleic acid, benzene 1,3,5-tricarboxylic acid, and carboxymethyloxysuccinic acid, and soluble salts thereof.

Citrate builders, e.g., citric acid and soluble salts thereof (particularly sodium salt), are polycarboxylate builders of particular importance for heavy duty liquid detergent formulations, but can also be used in granular compositions.

Other carboxylate builders include the carboxylated carbohydrates disclosed in U.S. Patent 3,723,322, Diehl, issued March 28, 1973, incorporated herein by reference.

Also suitable in the detergent compositions of the present invention are the 3,3-dicarboxy-4-oxa-1,6-hexanedioates and the related compounds disclosed in U.S. Patent 4,566,984, Bush, issued January 28, 1986, incorporated herein by reference. Useful succinic acid builders include the $C_5$-$C_{20}$ alkyl succinic acids and salts thereof. A particularly preferred compound of this type is dodecenylsuccinic acid. Alkyl succinic acids typically are of the general formula $R\text{-}CH(COOH)CH_2(COOH)$ i.e., derivatives of succinic acid, wherein R is hydrocarbon, e.g., $C_{10}$-$C_{20}$ alkyl or alkenyl, preferably $C_{12}$-$C_{16}$ or wherein R may be substituted with hydroxyl, sulfo, sulfoxy or sulfone substituents, all as described in the above-mentioned patents.

The succinate builders are preferably used in the form of their water-soluble salts, including the sodium, potassium, ammonium and alkanolammonium salts.

Specific examples of succinate builders include: laurylsuccinate, myristylsuccinate, palmitylsuccinate, 2-dodecenylsuccinate (preferred), 2-pentadecenylsuccinate, and the like. Laurylsuccinates are the preferred builders of this group, and are described in European Patent Application 86200690.5/0,200,263, published November 5, 1986.

Examples of useful builders also include sodium and potassium carboxymethyloxymalonate, carboxymethyloxysuccinate, cis-cyclo-hexane-hexacarboxylate, cis-cyclopentane-tetracarboxylate, water-soluble polyacrylates (these polyacrylates having molecular weights to above about 2,000 can also be effectively utilized as dispersants), and the copolymers of maleic anhydride with vinyl methyl ether or ethylene.

Other suitable polycarboxylates are the polyacetal carboxylates disclosed in U.S. Patent 4,144,226, Crutchfield et al., issued March 13, 1979, incorporated herein by reference. These polyacetal carboxylates can be prepared by bringing together, under polymerization conditions, an ester of glyoxylic acid and a polymerization initiator. The resulting polyacetal carboxylate ester is then attached to chemically stable end groups to stabilize the polyacetal carboxylate against rapid depolymerization in alkaline solution, converted to the corresponding salt, and added to a surfactant.

Polycarboxylate builders are also disclosed in U.S. Patent 3,308,067, Diehl, issued March 7, 1967, incorporated herein by reference. Such materials include the water-soluble salts of homo- and copolymers of aliphatic carboxylic acids such as maleic acid, itaconic acid and methylenemalonic acid.

Other organic builders known in the art can also be used. For example, monocarboxylic acids, and soluble salts thereof, having long chain hydrocarbyls can be utilized. These would include materials generally referred to as "soaps." Chain lengths of $C_{10}$-$C_{20}$ are typically utilized. The hydrocarbyls can be saturated or unsaturated.

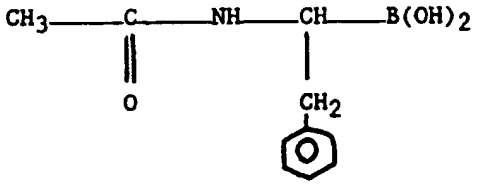
Other optional ingredients include soil release agents, chelating agents, clay soil removal/anti redeposition agents, polymeric dispersing agents, brighteners, suds suppresors, solvents and aesthetic agents.

The detergent composition herein can be formulated as a variety of compositions, for instance as laundry detergents as well as hard surface cleaners or dishwashing compositions.

## Examples

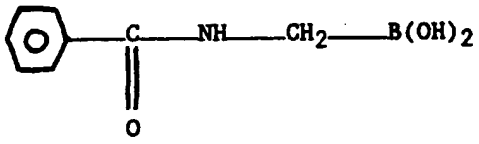
Following compositions 1-20 are made by mixing the listed ingredients in the listed proportions. Al percentages are by weight of the total compositions. In the following examples, the following α-amino boronic acids were used:

α-amino boronic acid 1 :



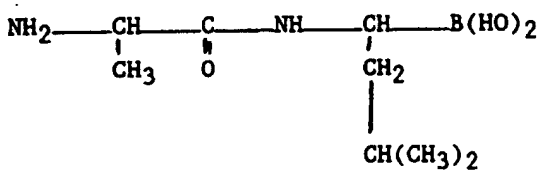
i.e. an α-amino boronic acid according to the present invention, where P is H, R is -$CH_2$-  , and the N terminal end of the α-amino boronic acid is protected by an acetyl group (1-acetamido 2-phenyl ethane-1- boronic acid).

α-amino boronic acid 2 :



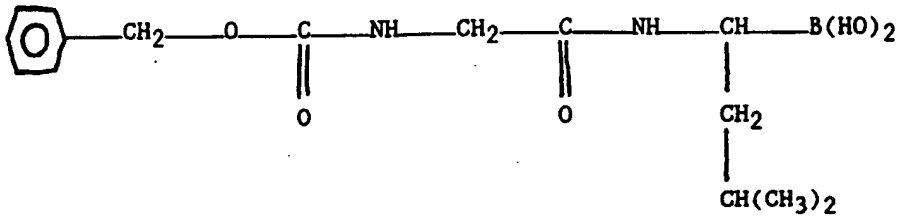
i.e. an α-amino boronic acid according to the present invention, wherein P is H, R is H, and the N terminal end of the α-amino boronic acid is protected by a benzoyl group (1-benzoylamido methane boronic acid).

α-amino boronic acid 3 :



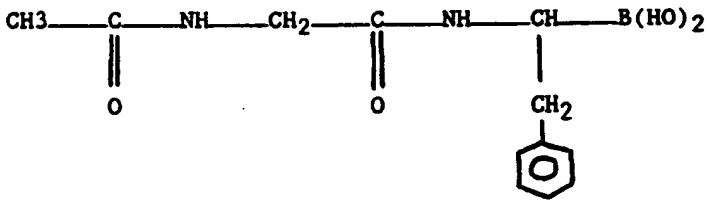
i.e. an α-amino boronic acid according to the present invention, wherein P is Ala, R is $-CH_2-CH(CH_3)_2$.

α-amino boronic acid 4 :



i.e. an α-amino boronic acid according to the present invention, wherein P is Gly, and R is $-CH_2-CH(CH_3)_2$, and the N terminal end of the α-amino boronic acid is protected by a benzyloxycarbonyl group.

α-amino boronic acid 5 :



i.e. an α-amino boronic acid according to the present invention, wherein P is Gly, R is $-CH_2-$  , and the N terminal end of the α-amino boronic acid is protected by an acetyl group.

| Ingredients | Compositions | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| - Linear alkyl benzene sulfonate | 0 | 12 | 7 | 0 | 6 | 7 | 8 |
| - Sodium $C_{12-15}$ alkyl sulfate | 5 | 2 | 2 | 0 | 3 | 3 | 2 |
| - $C_{14-15}$ alkyl 2.5 times ethoxylated sulfate | 6 | 0 | 0 | 11 | 2 | 2 | 0 |
| - $C_{12}$ glucose amide | 6 | 0 | 0 | 8 | 6 | 6 | 0 |
| - $C_{12-15}$ alcohol 7 times ethoxylated | 7 | 8 | 0 | 5 | 0 | 0 | 0 |
| - $C_{12-15}$ alcohol 5 times ethoxylated | 1 | 0 | 0 | 0 | 0 | 5 | 8 |
| - Oleic acid | 3 | 2 | 0 | 0 | 0 | 0 | 0 |
| - Citric acid | 5 | 3 | 9 | 3.5 | 9 | 13 | 15 |
| - $C_{12-14}$ alkenyl substituted succinic acid | 2 | 10 | 5 | 3 | 5 | 7 | 6 |
| - Sodium Hydroxide | 4 | 6 | 8 | 4 | 8 | 11 | 11 |
| - Ethanol | 3 | 4 | 4 | 3 | 3 | 4 | 5 |
| - Monoethanolamine | 0 | 0 | 5 | 2 | 0 | 8 | 10 |
| - 1,2-propane diol | 5 | 2 | 3 | 3 | 3 | 1 | 2 |
| - Sodium cumene sulfonate | 1 | 1 | 0 | 0 | 1 | 2 | 0 |
| - Diethylene triamine penta (methylene phosphonic acid) | 0 | 0.5 | 0 | 1 | 0.7 | 0 | 0.7 |
| - Amylase (143 KNU/g) | 0.1 | 0.1 | 0 | 0.1 | 0 | 0.2 | 0.1 |
| - Lipolase® (100KLU/g commercial solution) | 0 | 0 | 0.4 | 0.2 | 0.3 | 0 | 0.3 |
| - Protease B (34 g/L Commercial solution) | 0 | 0 | 0 | 0.3 | 0.2 | 0 | 0.5 |
| - Savinase® (Commercial solution) | 0.4 | 0.4 | 0 | 0 | 0 | 0.5 | 0 |
| - Maxacal® (Commercial solution) | 0 | 0 | 0.3 | 0 | 0 | 0 | 0 |
| - Carenzyme® (Experimental sample) | 0.5 | 0 | 0 | 0.5 | 0.5 | 0 | 0 |
| - α-amino boronic acid 1 | 0 | 0 | 0 | 0.01 | 0 | 0.03 | 0 |
| - α-amino boronic acid 2 | 0.08 | 0 | 0.15 | 0 | 0 | 0 | 0 |
| - α-amino boronic acid 3 | 0 | 0.03 | 0 | 0 | 0 | 0 | 0 |
| - α-amino boronic acid 4 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0.05 |
| - $CaCl_2$ | 0 | 0.01 | 0 | 0.01 | 0.01 | 0 | 0.02 |
| - Soil release polymers | 1 | 0.5 | 0 | 0.5 | 0 | 0 | 0.5 |
| - Fatty acids | 4 | 0 | 0 | 3 | 0 | 0 | 5 |
| - Water and minors | Balance to 100% | | | | | | |

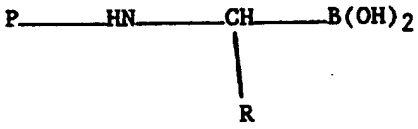
| Ingredients | Compositions | | | | | | |
|---|---|---|---|---|---|---|---|
| | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| - Linear alkyl benzene sulfonate | 0 | 15 | 7 | 9 | 8 | 10 | 10 |
| - Sodium $C_{12-15}$ alkyl sulfate | 4 | 5 | 2 | 1.75 | 0 | 3 | 2 |
| - $C_{14-15}$ alkyl 2.5 times ethoxylated sulfate | 8 | 2 | 0 | 2 | 0 | 0 | 0 |
| - $C_{12}$ glucose amide | 0 | 6 | 0 | 7 | 0 | 0 | 0 |
| - $C_{12-15}$ alcohol 7 times ethoxylated | 2 | 0 | 0 | 0.5 | 0 | 11.6 | 9 |
| - $C_{12-15}$ alcohol 5 times ethoxylated | 2 | 0 | 8 | 0 | 8 | 0 | 0 |
| - Oleic acid | 2 | 0 | 0 | 0 | 3.5 | 2.5 | 0 |
| - Citric acid | 0 | 10 | 9 | 9 | 4 | 1 | 5 |
| - $C_{12-14}$ alkenyl substituted succinic acid | 8 | 11 | 0 | 12 | 0 | 0 | 4 |
| - Sodium Hydroxide | 5 | 9 | 9 | 10 | 9 | 3.5 | 5 |
| - Ethanol | 3 | 6 | 4 | 4 | 3 | 6 | 4 |
| - Monoethanolamine | 0 | 0 | 6 | 12 | 0 | 8 | 0 |
| - 1,2-propane diol | 2 | 3 | 2 | 3 | 2 | 1.5 | 5 |
| - STPP | 6 | 0 | 20 | 0 | 0 | 10 | 0 |
| - Zeolite | 18 | 0 | 0 | 0 | 26 | 0 | 0 |
| - Sodium cumene sulfonate | 0 | 2 | 0 | 2 | 1 | 3 | 0 |
| - Diethylene triamine penta (methylene phosphonic acid) | 0 | 0 | 1 | 0.5 | 0 | 0.8 | 0.7 |
| - Amylase (143 KNU/g) | 0 | 0.2 | 0 | 0.2 | 0.05 | 0.1 | 0 |
| - Lipolase® (100KLU/g commercial solution) | 0 | 0.5 | 0.5 | 0.3 | 0.2 | 0.3 | 0 |
| - Protease B (34 g/L Commercial solution) | 0 | 0.3 | 0 | 0.2 | 0 | 0 | 0.3 |
| - Savinase® (Commercial solution) | 0.5 | 0 | 0 | 0 | 0.5 | 0.5 | 0 |
| - Maxacal® (Commercial solution) | 0 | 0 | 0.3 | 0 | 0 | 0 | 0 |
| - Carenzyme® (Experimental sample) | 0.3 | 0 | 0.5 | 0.5 | 0 | 0 | 0 |
| - α-amino boronic acid 5 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0 |
| - α-amino boronic acid 1 | 0.05 | 0.1 | 0 | 0 | 0 | 0 | 0.1 |
| - α-amino boronic acid 3 | 0 | 0 | 0.15 | 0 | 0 | 0.05 | 0 |
| - α-amino boronic acid 2 | 0 | 0 | 0 | 0.2 | 0 | 0 | 0 |
| - $CaCl_2$ | 0 | 0.01 | 0 | 0.01 | 0.01 | 0.02 | 0 |
| - Soil release polymers | 1 | 0.5 | 0 | 0 | 0.5 | 0.5 | 0 |
| - Fatty acids | 5 | 0 | 0 | 0 | 0 | 12 | 0 |
| - Water and minors | - - - - - Balance to 100%- - - - - - | | | | | | |

| Ingredients | Compositions | | | | | |
|---|---|---|---|---|---|---|
| | 15 | 16 | 17 | 18 | 19 | 20 |
| - Linear alkyl benzene sulfonate | 18 | 5 | 7 | 9 | 8 | 10 |
| - Sodium $C_{12-15}$ alkyl sulfate | 2 | 5 | 2 | 1.75 | 0 | 3 |
| - $C_{14-15}$ alkyl 2.5 times ethoxylated sulfate | 0 | 2 | 0 | 2 | 0 | 0 |
| - C12 glucose amide | 0 | 6 | 0 | 7 | 0 | 0 |
| - $C_{12-15}$ alcohol 7 times ethoxylated | 14 | 0 | 0 | 0.5 | 0 | 12 |
| - $C_{12-15}$ alcohol 5 times ethoxylated | 0 | 0 | 8 | 0 | 8 | 0 |
| - Oleic acid | 0 | 0 | 0 | 0 | 3.5 | 2.5 |
| - Citric acid | 8 | 10 | 9 | 9.5 | 4 | 1 |
| - $C_{12-14}$ alkenyl substituted succinic acid | 0 | 11 | 0 | 11.5 | 0 | 0 |
| - Sodium Hydroxide | 0 | 9 | 9 | 9.8 | 9 | 3.5 |
| - Ethanol | 7 | 6 | 4 | 4 | 3 | 6 |
| - Monoethanolamine | 14 | 0 | 0 | 0 | 12 | 0 |
| - Triethanolamine | 0 | 0 | 0 | 8 | 0 | 6 |
| - 1,2-propane diol | 4 | 3 | 2 | 3 | 2 | 1.5 |
| - Tartrate monosuccinate | 0 | 0 | 15 | 0 | 17 | 0 |
| - Diethoxylated poly (1,2-propylene terephtalate) | 0 | 1.0 | 0.5 | 0.7 | 0 | 0.5 |
| - Diethylene triamine penta (methylene phosphonic acid) | 1 | 0 | 1 | 1 | 0.5 | 0.8 |
| - Amylase (143 KNU/g) | 0.1 | 0.2 | 01 | 0.2 | 0.05 | 0 |
| - Lipolase® (100KLU/g commercial solution) | 0.2 | 0.5 | 0.5 | 0.3 | 0.2 | 0 |
| - Protease B (34 g/L Commercial solution) | 0.4 | 0.3 | 0 | 0.2 | 0 | 0.5 |
| - Savinase® (Commercial solution) | 0 | 0 | 0 | 0 | 0.5 | 0 |
| - Maxacal® (Commercial solution) | 0 | 0 | 0.3 | 0 | 0 | 0 |
| - Carenzyme® (Experimental sample) | 0 | 0 | 0.5 | 0.5 | 0 | 0 |
| - α-amino boronic acid 1 | 0 | 0.2 | 0 | 0.05 | 0 | 0 |
| - α-amino boronic acid 2 | 0 | 0 | 0.1 | 0 | 0 | 0 |
| - α-amino boronic acid 3 | 0.3 | 0 | 0 | 0 | 0 | 0.1 |
| - α-amino borohic acid 5 | 0 | 0 | 0 | 0 | 0.01 | 0 |
| - CaCl2 | 0.01 | 0.01 | 0 | 0.01 | 0.01 | 0.02 |
| - Soil release polymer | 1 | 0.5 | 0 | 0 | 0 | 0.5 |
| - Fatty acids | 8 | 0 | 0 | 0 | 0 | 12 |
| - Water & minors | - - - -Balance to 100%- - - | | | | | |

What is claimed is:

1. A liquid aqueous detergent composition comprising:
   - from 1% to 80% of a detersive surfactant,
   - from 0.0001% to 0.3% of active proteolytic enzyme or mixtures thereof,

characterized in that it further comprises from about 0.0001% to 5% of an α-amino boronic acid of the formula:



wherein R is selected from the side chains of the twenty amino acids, and P is H or $(AA2)_m$—$(AA1)_n$—, wherein (AA1) and (AA2) are identical or different amino acids, and n and m are 1 or 0, independently, said α-amino boronic acid possibly comprising an N-terminal protecting group, and mixtures thereof.

2. A composition according to claim 1 wherein P is H.

3. A composition according to any of the preceding claims wherein the N-terminal end of the α-amino boronic acid is protected by a protecting group selected from acetyl, benzoyl, trifluoroacetyl, methoxysuccinyl, aromatic urethanes and aliphatic urethanes.

4. A composition according to claim 3 wherein said protecting group is acetyl or benzoyl.

5. A composition according to any of the preceding claims wherein R is H-, $CH_3$-, $(CH_3)_2CH$-, $(CH_3)_2CH$-$CH_2$-, $CH_3$-$CH_2$-$(CH_3)CH$ and  .

6. A composition according to the preceding claims wherein said α-amino boronic acid is selected from 1-acetamido 2-phenylethane -1-boronic acid and 1-benzoylamido methane.

7. A composition according to any of the preceding claims which comprises from 0.001% to 1.0% of said α-amino boronic acid or mixtures thereof, most preferably from 0.005% to 0.5%.

8. A composition according to any of the preceding claims, comprising from 0.0005% to 0.2% of active proteolytic enzyme or mixture thereof, most preferably from 0.002% to 0.1%.

9. A composition according to any of the preceding claims wherein said proteolytic enzyme is selected from the group consisting of Alcalase $^{R}$, Subtilisin BPN', Protesase A, Protease B, and mixtures thereof.

10. A composition according to any of the preceding claims which further comprises a performance enhancing amount of a detergent compatible second enzyme selected from the group consisting of lipase, amylase, cellulase, and mixtures thereof.

11. A composition according to claim 10 wherein said second enzyme is lipase.

12. A composition according to claim 11, wherein the lipase is obtained by cloning the gene from Humicola Lanuginosa and expressing the gene in Aspergillus Oryzae.

13. A composition according to claim 11 which comprises from 10 to 18000 lipase units per gram.

14. A composition according to claim 13 which comprises from 60 to 6000 units per gram.

15. A composition according to claim 10 wherein said second enzyme is a cellulase derived from Humicola Insolens.

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/07123

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(5) :C11D 3/386, 3/02
US CL :252/174, 12, DIG. 12, 135, DIG. 14, 544
According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 252/174, 12, DIG. 12 135, DIG. 14, 544

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Please See Extra Sheet.

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | US, A, 4,537,707 (Severson Jr.) 27 August 1985. See col. 7, line 1- col. 8, line 5, col. 8, lines 14-16. | 1-2 |
| A | US, A, 4,842,769 (Shulman et al) 27 June 1989. See col. 3, lines 45-57. | 1-2 |
| Y | US, A, 5,030,378 (Vengas) 9 July 1991. See col. 8, line 65- col. 9, line 5. | 1-2 |
| P,A | WO, A 92/19709 (Panandiker) 12 November 1992. See col. 8, lines 9-15. | 1-2 |
| P,A | EP, A, 0,511,456 (Lenoir et al) 04 November 1992. See col. 3, lines 15-21. | 1-2 |

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

| | | | |
|---|---|---|---|
| * | Special categories of cited documents: | "T" | later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention |
| "A" | document defining the general state of the art which is not considered to be part of particular relevance | "X" | document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone |
| "E" | earlier document published on or after the international filing date | "Y" | document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art |
| "L" | document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) | "&" | document member of the same patent family |
| "O" | document referring to an oral disclosure, use, exhibition or other means | | |
| "P" | document published prior to the international filing date but later than the priority date claimed | | |

| | |
|---|---|
| Date of the actual completion of the international search<br>13 SEPTEMBER 1993 | Date of mailing of the international search report<br>15 OCT 1993 |
| Name and mailing address of the ISA/US<br>Commissioner of Patents and Trademarks<br>Box PCT<br>Washington, D.C. 20231<br>Facsimile No. NOT APPLICABLE | Authorized officer<br>KERY A. FRIES<br>Telephone No. (703) 308-0687 |

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/07123

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| P,A | WO, A, 92/19707 (Panandiker) 12 November 1992. See col. 1, lines 5-25, col. 4, line 22- col. 8 line 9. | 1-2 |
| Y | EP, A, 0,293,881 (Kettner) 07 December 1988. See col. 3, lines 35-55. | 1-2 |

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/07123

**Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)**

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 3-15
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

B. FIELDS SEARCHED
Electronic data bases consulted (Name of data base and where practicable terms used):

APS: Amino (5a) Boron? or Amino (5A) Bornoic Enzymes Surface acitve or Surfactant or Detergent Active

CA: See Library Search

Paper _____

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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES
(Administrative Patent Judge Richard E. Schafer)

RICHARD **KROCZEK**

Junior Party
(Applications 09/509,283, 09/823,307, and 09/972,524)

v.

TAKUYA **TAMATANI**
and
KATSUNARI TEZUKA

Senior Party
(Applications 09/383,551, 09/561,308, and 10/301,056)

Patent Interference No. 105,168

**DECLARATION OF JEFFREY A. BLUESTONE, PH.D.**

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I, Jeffrey A. Bluestone, Ph.D., hereby declare as follows:

1. I am Director of the University of California San Francisco (UCSF) Diabetes Center and Immune Tolerance Network and the AW and Mary Clausen Distinguished Professor in Metabolism and Endocrinology at UCSF. I received a Bachelors of Science degree from Cook College at Rutgers University in 1974, a Masters of Science degree from Rutgers - State University, NJ, in 1977, and a Ph.D. in Immunology from the Cornell Graduate School of Medical Science (Sloan-Kettering Division), Cornell University, in 1980. After obtaining my Ph.D., I completed postdoctoral studies at the Immunology Branch of the National Cancer Institute. I have been engaged in conducting professional scientific research in molecular biology and immunology since 1980. I have authored or co-authored over 275 published papers relating to original research, in which I participated. I have served on the review board of eleven scientific journals, including serving as section and deputy editors of *Journal of Immunology*, *Immunity*, *Journal of Immunotherapy* and *American Journal of Transplantation*. A copy of my curriculum vitae, which details my background and experience, is provided as Exhibit A.

2. The following documents are cited herein:

Exhibit A - Curriculum Vitae, Jeffrey A. Bluestone, Ph.D.
Exhibit B - Eljaschewitsch et al., *Immunobiol., 194(1-3)*, 27 (1995)
Exhibit C - Tezuka et al. Poster Presentation (1994) and English-language translation thereof
Exhibit D - Redoglia et al., *Eur. J. Immunol., 26*(11), 2781-2789 (1996)
Exhibit E - Gonzalo et al, *Nature Immunology*, *2*(7), 597-604 (2001)

3. In my opinion, the art to which the subject matter of the above-identified patent applications pertains is immunology. In about 1997, I believe that a person of ordinary skill in the art would have been a person with either an M.D. degree or a Ph.D. degree in immunology. The person of ordinary skill would additionally have had an appreciation of mechanisms of lymphocyte costimulation. By virtue of my education

and experience in immunology in about 1997, I consider myself to have been aware of the knowledge of a person of ordinary skill in the field of immunology at that time.

4. U.S. Patent Application Nos. 09/383,551, 09/561,308, and 10/301,056 (Tamatani) ("the Tamatani applications") disclose the amino acid sequence of the human JTT-1 polypeptide, which is referenced therein as SEQ ID NO: 2. U.S. Patent Application Nos. 09/509,283, 09/823,307, and 09/972,524 (Kroczek) ("the Kroczek applications") disclose the amino acid sequence of a human 8F4 polypeptide, which is referenced therein as SEQ ID NO: 2.

5. The human JTT-1 polypeptide defined by SEQ ID NO: 2 in the Tamatani applications and the human 8F4 polypeptide defined by SEQ ID NO: 2 in the Kroczek applications are the same polypeptide. The polypeptide that is referred to by Tamatani as the human JTT-1 polypeptide and by Kroczek as the human 8F4 polypeptide is commonly known as the human "inducible costimulatory molecule (ICOS)."

6. The human ICOS polypeptide is the only protein that occurs on two-signal-activated human T lymphocytes and is recognized by the 8F4 antibody. It is my belief that the immunoprecipitation/purification studies taught in Example 2 and Figure 1 of the Kroczek applications lead to the conclusion that human ICOS is uniquely identified merely by its occurrence on two-signal-activated human T lymphocytes and by its recognition by the 8F4 antibody.

7. I have been provided with the language of Proposed Counts 1-3 of Joint Motion 2 and Proposed Counts 1 and 2 of Contingent Joint Motion 3. Proposed Counts 1-3 of Joint Motion 2 set forth three categories of subject matter: (a) a method of inhibiting the activation or costimulation of human T lymphocytes using an antibody against human ICOS, (b) an antibody against human ICOS, and (c) the human ICOS polypeptide and a nucleic acid encoding the human ICOS polypeptide. Proposed Counts 1 and 2 of Contingent Joint Motion 3 set forth the same categories of subject matter, except that categories (b) and (c) are combined in a single Count (i.e., Proposed Count 2).

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8. I have been asked to provide my opinion as to the subject matters of the Proposed Counts in view of the knowledge available to one of ordinary skill in the art as it existed before September, 1997.

9. An anti-human ICOS antibody is an antibody that recognizes (*e.g.*, binds) human ICOS. Antibodies, including anti-human ICOS antibodies, have many uses in the field of immunology, both in laboratory and clinical settings. This was true prior to September, 1997 and is still true. For example, antibodies are commonly used as reagents in affinity chromatography wherein an antibody's affinity to an antigen is exploited to isolate and purify antigens. Antibodies also are commonly used to concentrate antigens using immunoprecipitation. In addition, identification of proteinaceous antigens can be achieved by immunoblotting, wherein an antibody to, for example, human ICOS, is employed to detect the desired antigen in a mixture. Antigens can be linked to solid supports via antibodies adhered to a surface. Anti-ICOS antibodies also can be used to analyze the role of ICOS in disease. An antibody to human ICOS could be used in any of these ways. Thus, the mere disclosure of an anti-human ICOS antibody, without more, does not suggest any particular method of using the antibody. This is equally true now as it would have been prior to September, 1997.

10. Prior to September, 1997 and still today, polypeptides and nucleic acid molecules also have many uses in the field of immunology. For example, nucleic acids and the polypeptides encoded thereby can be used to produce antibodies, which can be used in any of the ways described in paragraph 8, above. Also, polypeptides and nucleic acids can be used as probes, and specific polypeptides and nucleic acids, such as the human ICOS polypeptide and nucleic acid, can be used to investigate diseases. The mere disclosure of a polypeptide or nucleic acid, such as the human ICOS polypeptide or nucleic acid, without more, does not suggest any particular method of using the polypeptide or a method of using an antibody against the polypeptide. This is equally true now as it would have been prior to September, 1997.

11. The recitation of the particular amino acid sequence of the human ICOS polypeptide, without more, does not indicate or suggest that the human ICOS polypeptide activates human T cell costimulation. Similarly, the recitation that the

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human ICOS polypeptide is a dimer that occurs on two-signal-activated lymphocytes and binds to a particular deposited antibody, without more, does not indicate or suggest that the human ICOS polypeptide activates human T cell costimulation. This is equally true now as it would have been prior to September, 1997, even taking in to account the collective teachings of Eljaschewitsch et al. (Exhibit B), Tezuka et al. (Exhibit C) and Redoglia et al. (Exhibit D).

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12. In 1995, Eljaschewitsch et al. (Exhibit B) disclosed the existence of a novel cell surface molecule expressed on activated human T cells, which molecule was designated "8F4" and is now known to be human ICOS. Eljaschewitsch et al. did not disclose the role of human ICOS in costimulation, the sequence or structure of human ICOS, or any other physical or functional characteristics of the human ICOS molecule. Furthermore, I am not aware of any other publication prior to September, 1997 that disclosed any physical or functional characteristics of human ICOS. Accordingly, to the best of my knowledge, the role of human ICOS in activation or costimulation of human T lymphocytes was unknown prior to September, 1997, and the Eljaschewitsch et al. publication would not have lead the artisan of ordinary skill at this time to conclude that the human ICOS polypeptide was involved in costimulation. Moreover, because the teachings of Eljaschewitsch et al. provide virtually no information regarding the structure or function of human ICOS, one of skill in the art would not be able to uniquely identify human ICOS by replicating the experiments described Eljaschewitsch et al.

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13. It is my understanding that in 1994, prior to the Eljaschewitsch et al. publication, Tezuka et al. displayed a poster-presentation in Japan. I have been provided with and have reviewed an English-language translation of a summary of the contents of the poster-presentation (Exhibit C). The poster presentation disclosed the existence of a molecule designated the "JTT-1 antigen" that was found on the surface of rat thymoma cells, as well as two antibodies to the antigen. The JTT-1 antigen was characterized by Tezuka et al. as a novel cell adhesion molecule. The configuration of the molecule as a dimer and the molecular weights of the dimer strands also were disclosed. It is now known (e.g., from the Tamatani patent applications) that the rat JTT-1 polypeptide disclosed in Tezuka et al. is the rat homolog of the human ICOS polypeptide. However, to the best of my knowledge, the relationship between the rat

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JTT-1 polypeptide of Tezuka et al. and the human ICOS polypeptide was not known prior to September, 1997. At that time, the disclosure of Tezuka et al. would not have led one of ordinary skill in the art at that time to conclude that the human ICOS polypeptide was involved in the activation or costimulation of T lymphocytes.

14. In 1996, Redoglia et al. (Exhibit D) disclosed the existence of a murine polypeptide involved in the costimulation of murine T lymphocytes, which polypeptide was designated "H4." Redoglia et al. also identified a hamster antibody that recognized the H4 polypeptide. This polypeptide later was found to be the murine homolog of human ICOS polypeptide. However, to the best of my knowledge, this was unknown prior to September, 1997. At that time, the disclosure of Redoglia et al. would not have led one of ordinary skill in the art at that time to conclude that the human ICOS polypeptide was involved in the activation or costimulation of T lymphocytes.

15. Because the relationships between the Eljaschewitsch's human polypeptide, Tezuka's rat polypeptide and Redoglia's murine polypeptide were unknown in September 1997, the discovery of the sequence of the human ICOS polypeptide or that the human ICOS polypeptide is a dimer that occurs on two-signal-activated lymphocytes and binds to a particular deposited antibody, even in view of the general knowledge available at that time, would not have led one of ordinary skill in the art to conclude that the human ICOS polypeptide was involved in the activation or costimulation of T lymphocytes.

16. It is known that some antibodies to costimulatory molecules other than human ICOS could inhibit T lymphocyte costimulation, while other antibodies to different costimulatory molecules do not inhibit T lymphocyte costimulation. Also, with respect to certain costimulatory molecules, some antibodies will inhibit costimulation and others will not.

17. Specifically, in the case of anti-human ICOS antibodies, it is known that only some anti-human ICOS antibodies can inhibit the activation or costimulation of T lymphocytes. For example, Gonzalo et al. (Exhibit E) describes a rat anti-ICOS antibody, IC10, which does not bind the same portion of ICOS as B7RP-1, the natural ligand to ICOS. Consequently, IC10 does not block the binding of the ICOS ligand, B7h

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16. The lack of predictability regarding anti-ICOS antibodies is further evidenced by research performed after September, 1997.

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(i.e., B7RP-1), to the rat ICOS polypeptide, and does not inhibit cytokine production in T cells, thereby indicating that the IC10 antibody does not inhibit activation of T lymphocytes (Exhibit E, paragraph bridging pages 597 and 598, page 598, paragraph bridging columns 1 and 2, and Figures 1 and 2).

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17. In view of the low predictability of the art, one of ordinary skill in the art prior to September, 1997 would not have been able to predict with any

18. Any given antibody binds to and, therefore, recognizes a particular amino acid sequence referred to in the art as an epitope. An epitope is generally made up of a very short amino acid sequence, and the antibody recognizes some structural form of the short amino acid sequence (e.g., a native or denatured form of the sequence). Thus, an antibody might suggest to one of ordinary skill in the art the sequence of the epitope to which the antibody binds. However, neither the sequence nor other structural attributes of the larger polypeptide in which the epitope resides could be discerned from the sequence of the epitope. Thus, the antibody to a protein (e.g., the structure or sequence of an antibody to a protein) does not disclose or suggest the structure or sequence of the protein itself.

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19. I hereby declare that all statements made herein of my own knowledge are true, that all statements made on information and belief are believed to be true, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Respectfully submitted,

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Jeffrey A. Bluestone, Ph.D.

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14. The above references considered together and in view of the general knowledge available in the art prior to

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15. The predictability in the art of immunology was low before and after September, 1997. For example, it

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